LAMONT GEOLOGICAL OBSERVATORY

COLUMBIA UNIVERSITY

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1 January 1962 - 31 December 1962

CONTRACT Nonr 266 (48)

OCEANOGRAPHIC RESEARCH

TABLE OF CONTENTS

1. INTRODUCTION

A major part of the marine activities at Lamont Observatory are supported by the Office of Naval Research through Contract Nonr 266 (48). This contract has succeeded a number of contracts dealing with individual studies or techniques and covers a broad range of activities. Included among them are marine geophysics, comprising seismology, gravity, magnetics, and heat flow; marine geology, including submarine topography and physiography, structural geology, and marine sedimentation; marine biology, covering ecology of living planktonic animals, abyssal fauna, microbiology, and bacteriology; and physical and chemical oceanography, including the use of radioisotopes as current indicators.

The program supported by this contract is integrated with complementary programs supported by other government agencies and from private sources. The purpose of all these studies is to determine the nature of the marine environment, its structure and its history, and the processes which affect it in the present or have affected it in the past.

2. SHIPS AND CRUISES

VEMA departed from New York in December 1961 for her 18th cruise. The cruise was just over one year in duration during which VEMA again circumnavigated the Earth. (See Fig. 1)

The vessel stopped first in Bermuda and then conducted a detailed grid survey of an area between Bermuda and Puerto Rico, using sounder, profiles, and magnetometer. From Puerto Rico she continued south via Recife, Brazil, and Buenos Aires, Argentina, to Punta Arenas where she joined forces with the Chilean research vessel YELCHO for joint exercises in the Drake Passage

the Scotia Sea. The vessels returned to port at Puerto Williams, Chile, YELCHO continuing to Valparaiso while VEMA journeyed to Ushuaia, Argentina, to meet the Argentine vessel GENERAL ZAPIOLA for six weeks of work in the Argentine Basin.

Upon completion of this portion of the cruise in Buenos Aires, VEMA continued on to the Indian Ocean via Capetown to participate in the International Indian Ocean Expedition. It had originally been intended that she journey through the Red Sea and Mediterranean and return to New York across the North Atlantic but the records produced by the seismic profiles indicated that a more profitable track would be across the Pacific. Since all of the major oceans could be examined on such a track, she was rerouted across the Indian Ocean, the South Australian Basin and the Tasman Sea to New Zealand. From here she ran up the Hikurangi and Tonga-Kermadec trenches and east to Tahiti, then across the eastern Pacific to Mexico and Panama.

From Panama VEMA journeyed north through the Caribbean to the Gulf of Mexico, where the eastern half was covered, and through the Straits of Florida to Nassau. After Nassau she returned briefly to the grid area, then rendezvoused with two submarines for exercises near Bermuda. The last leg of the cruise covered the New England-Kelvin seamount group which extends from the continental shelf off Massachusetts to the Bermuda Rise.

This was VEMA's longest cruise, covering some 56,000 miles in all of the major oceans over a period of 373 days.

1962 was marked by the addition of AGOR-3, ROBERT CONRAD, to the Lamont fleet. CONRAD was delivered to Lamont by the Navy in November and departed 3 December on her first cruise. Although the cruise was interrupted by a problem of fuel contamination, a program of continuous seismic reflection

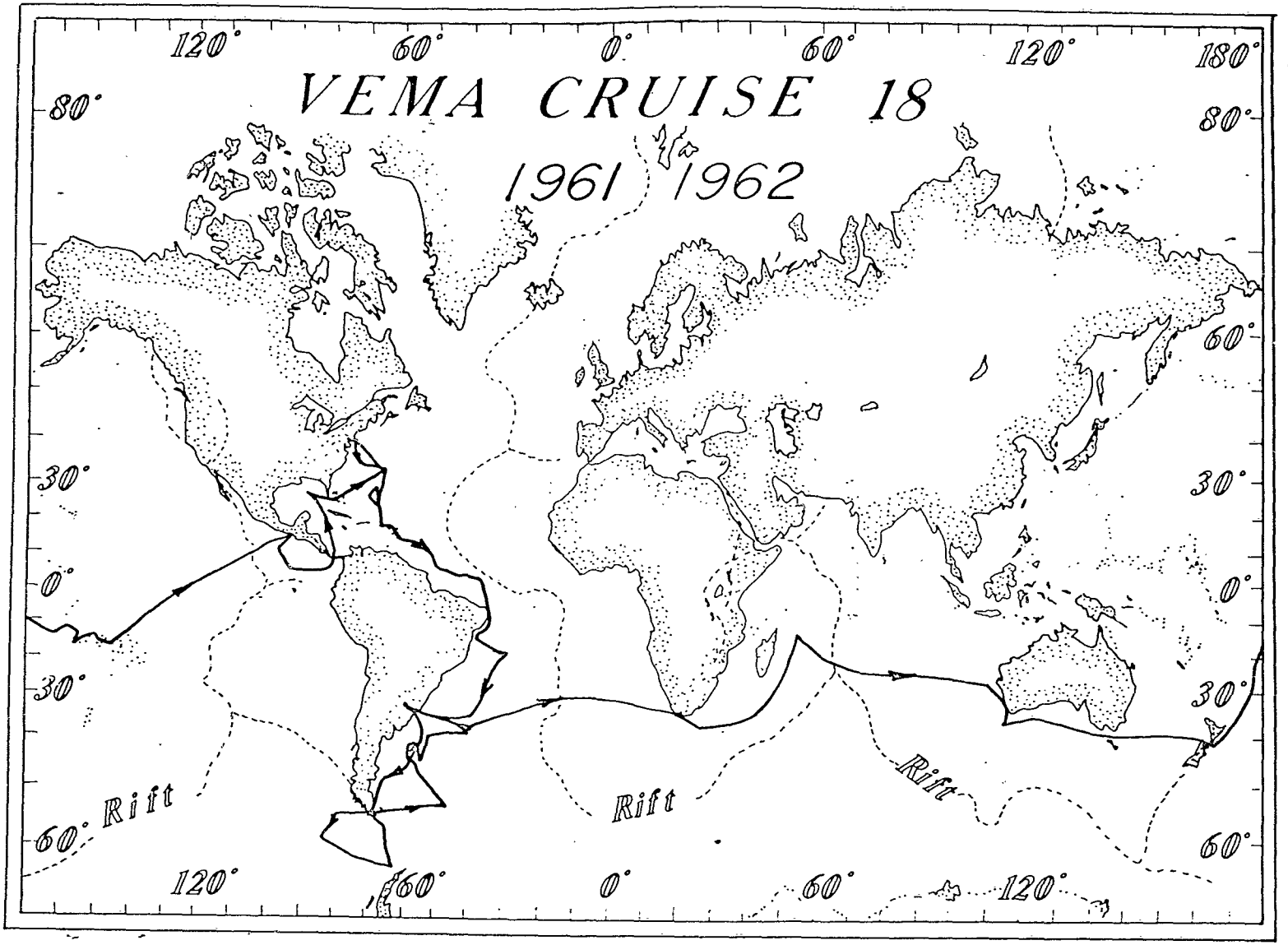
VEMA CRUISE 18
1961 1962
120°
60°
0°
60°
120°
180°
80°
30°
0°
30°
60°
Rift
Rift
Rift

Fig. 1

profiling was realized during the majority of her time at sea. The first cruise lasted until 22 December when CONRAD returned to Gibbs Shipyard for correction of various flaws in design or construction, alterations necessary for the work of this laboratory, and additions of new equipment. It appears that she will be a useful addition to the oceanographic fleet when she is shaken down and fully equipped with the proper tools for deep sea research although there is some concern about the ratio of scientific staff to operating crew.

JOSEPH GOLDBERGER operated in local waters, principally in Long Island Sound and on the shelf off New York and New Jersey, during the summer of 1962. Most of the time was spent in a magnetic and sparker survey of Long Island and Block Island Sounds with some time devoted to coring, photography, current measurements, and turbo drilling. In late December GOLDBERGER was laid up for the winter.

The small schooner GRACE was disposed of during the period covered by this report as she proved inadequate for deep sea work.

3. MARINE GEOPHYSICS

a. Seismic reflection and refraction.

The seismic profiler was used continuously aboard R.V. VEMA for her entire cruise and aboard R.V. CONRAD for the short period she was in operation during 1962. Equipment was also placed on R.V. SIR HORACE LAMB for work in the Bermuda area, on YELCHO and GENERAL ZAPIOLA during the joint exercises with VEMA, and aboard R.V. CRAWFORD of the Woods Hole Oceanographic Institution for several trips in the northwest Atlantic. The results of this work have greatly increased our knowledge of the thickness and distribu-

tion of sediments in the ocean basins. One of its most striking discoveries has been a seemingly world-wide reflecting horizon within the basin sediments. It is usually quite flat and may be a discontinuity in composition, due to pressure and compaction, or a result of some world-wide event in the past. It has been termed "Horizon A" for want of a more definitive term.

The distribution of the sediment is particularly puzzling. While in such areas as the Gulf of Mexico an explanation is simple, in others it is not. In the Argentine Basin, for example, the greatest accumulation is in the central part of the basin rather than near the continent, and off the Blake Plateau the Outer Ridge appears to be made up of essentially undisturbed sediments, separated from the plateau by the Blake-Bahama Basin, rather than of tectonic origin. Another problem is that the sediments are not conformable with the topography of the underlying rock, but are sometimes rather bare, as if worked by currents, and sometimes rough, but with a different form from that of the bedrock. It would appear that non-tectonic processes of greater magnitude than previously recognized are at work on the ocean floor. It is also evident that past estimates of sediment thickness in the ocean basins have been in considerable error and that an average figure is meaningless. The embarrassingly small thicknesses suggested in the past for areas free from turbidity current effects have been found to be even smaller and more difficult to explain.

In shallower water, the sparker and an Edgerton boomer were used with good results. Long Island Sound has now been completely surveyed by sparker, and contour maps have been prepared on sub-surface horizons. The subbottom topography is very similar to that of the coast of Norway and may

owe its character to similar glacial processes. The results coordinate very well with the borehole data on buried channels under Long Island collected by the Ground Water Branch of the U.S. Geological Survey in Mineola, Long Island.

A number of tracks across the Blake Plateau were made with the profiler using blasting caps and the Edgerton boomer as a sound source. These experiments have yielded very detailed results which show that the upper sediments under the Blake dip to the west with a bedrock ridge present at shallow depths at the edge of the Blake. These results, together with others mentioned earlier, were presented at the American Geophysical Union meetings in a symposium organized and chaired by J. Ewing.

Refraction measurements were limited to twelve profiles taken by VEMA and ZAPIOLA in the Argentine Basin since the vessels operated independently most of the time and because of the emphasis on reflection studies.

b. Gravity.

The operation of the Graf-Askania surface ship gravimeter mounted on a stable platform was continued on R.V. VEMA cruise 18. Measurements were made in the North Atlantic, South Atlantic, Indian and Pacific Oceans as well as the Caribbean Sea. The equipment functioned for all but three or four days in the one-year cruise. The gravimeter values at base stations in ports visited were considerably better than on previous VEMA cruises. Of twenty checks between consecutive ports, sixteen checks were good to 8 mgal. or better and thirteen checks were good to 6 mgal. or better.

An improvement put into operation during part of the cruise was the beam nulling servo system. This device holds the beam in a fixed position and measures the force necessary to do this as opposed to the older system

of measuring beam deflection. It reduces the time constant of the instrument from 5 minutes to 1 or 2 minutes (thereby improving considerably the response of the instrument to sharp gravity changes). It also eliminates the necessity of making frequent dial changes of the gravimeter which in turn eliminates the loss of the gravity record during the stabilizing period of about 30 minutes after every dial change. From use on this cruise it became apparent that the servo system supplied by Askania could itself be improved further. The chief improvement made after the cruise was an increase of its "period" from one minute to two minutes to increase its stability.

Reduction of data obtained by the sea gravimeter has been automated. The gravity records and the navigation are still read manually, punched on paper tape and cards and fed to a digital computer, IBM 1620. The reduction of free-air anomalies and the plotting with respect to distance are now done automatically.

Studies of the cross-coupling effect and other possible errors introduced in the gravity data on account of the motions of the ship are being carried out. Records of the ship's roll, pitch, heave, surge, and sway were made during VEMA cruise 18 and these are being digitized and analyzed on a computer to obtain the magnitude of the error effects. These measurements of the accelerations of the vessel are also being studied by the seismology group to determine what relationships, if any, exist between wave motion and microseismic noise on seismographs.

c. Magnetism.

The magnetic program includes measurements of spacial variations in the total intensity of the magnetic field, carried out aboard ships, and time variations of the geomagnetic field at fixed stations ashore.

During the period covered by this report field measurements were made during the entire cruise of VEMA and on CONRAD after her delivery in late November. A magnetic survey was made aboard GOLDBERGER in conjunction with a sparker survey of Long Island Sound and an instrument was mounted on YELCHO and later on ZAPIOLA for the operations in high southern latitudes.

The electronics of the marine magnetometer have been reduced considerably in size by transistorizing the system. This saves valuable space on the ships and allowed a deep towed magnetometer to be designed and constructed in a few days' time in early 1963 when such a device became necessary to search for THRESHER. Programs have been developed for reduction of the magnetic data and calculations of the effects of geologic structures by use of the IBM 1620 electronic computer available at the Laboratory.

Sufficient magnetic data have now been accumulated in a number of areas that structural trends are apparent and interpretations can be made. These include the Drake Passage-Tierra del Fuego-Palmer Peninsula region where VEMA data together with that collected aboard Argentine and Chilean vessels reveal strong magnetic trends associated with Andean deformation, and the Gulf of Mexico, where the eastern part, inadequately covered previously (Miller, 1956) has now been contoured. The measurement in Long Island Sound demonstrated that the Triassic basin of Connecticut extends in some form under Long Island Sound and the measurements off the east coast reveal an anomaly pattern essentially parallel to Appalachian structures of the general coastline. (See attached Fig. 2) These last further revealed a hitherto unsuspected transcurrent fault with right lateral movement of about 90 miles at latitude 40° N.

The station measurements were principally carried out at a location on

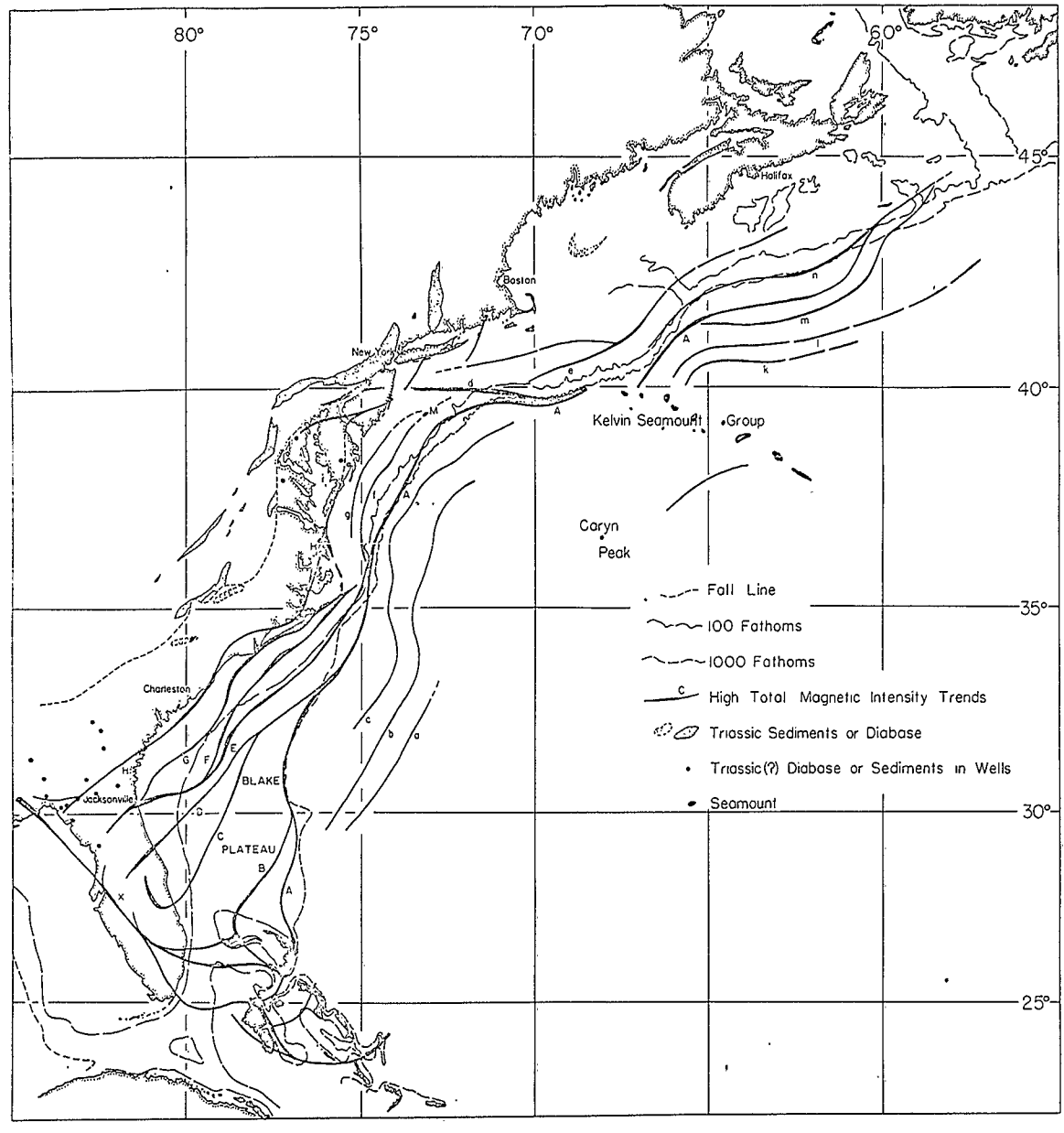
80°
75°
70°
60°
45°
40°
35°
30°
25°
Halifax
Boston
New York
Kelvin Seamount
Group
Caryn
Peak
Charleston
Jacksonville
BLAKE
PLATEAU
Fall Line
100 Fathoms
1000 Fathoms
High Total Magnetic Intensity Trends
Triassic Sediments or Diabase
Triassic(?) Diabase or Sediments in Wells
Seamount

Fig. 2

the coastal plain of southern New Jersey using rubidium vapor magnetometers. It should be noted that this station was destroyed by fire early 1963 during the extensive fires in the area caused by a very dry spring.

A series of measurements, which might be considered either marine or station, were carried out on the manned ice island in the Arctic Ocean. Simultaneous measurements were made using surface and subsurface magnetometers in a program partly supported by TO-48 and partly by the Air Force.

Correlations between surface magnetic measurements and those made by Explorer X have been carried out as well as studies of the effect on the magnetic field of the high nuclear explosion at Johnson Island.

Considerable instrumentation work was carried out to improve existing instruments and develop new ones. The improvements to the marine system were mentioned earlier and, in the same field, a recording ocean bottom magnetometer has been designed and is now nearly complete. Induction magnetometers have been developed for the New Jersey field station as well as a method of simultaneous operation of two rubidium vapor magnetometers and analysis of the records by computer techniques.

d. Heat Flow.

During cruise 18 of VEMA in 1962, approximately 160 heat flow stations were occupied, using the short-time constant, deep penetrating thermal gradient measuring device developed at Lamont. Sixty-four of these stations were made in the North and South Atlantic, including most of the Western Atlantic Basins, the Drake Passage and Scotia Sea, and a crossing of the South Atlantic at about 37° S. Twenty-eight measurements were made in the Indian Ocean in the major basins of the Central Indian Ocean and on three of the small ridges. Sixty-eight measurements were taken in the eastern Pacific,

including a profile of the East Pacific Ridge, and the Cocos Ridge near Panama. Conductivity measurements were made immediately after extrusion of the cores using the transient heated probe technique.

Special studies were made to determine the heating of the outer wall of the core pipe on penetration and the effect of convection of interstitial water on the conductivity measurements, and to investigate the anistrophy of sediments in the core samples.

Partial analyses of the above data, subject to small revisions, have been made. The Atlantic data taken during 1962, combined with earlier data, show very little variation within basins or between different basins. In the Western Atlantic, values from the North American Basin to the Argentine Basin vary between 1.3 - 1.5 microcalories/cm^2/sec. The only apparent systematic variation is from low values on the continental rises to gradually higher ones as the Mid-Atlantic Ridge is approached. High values of 5.4 in the North Atlantic and 1.95 - 2.10 in the South Atlantic were found on the Ridge with one of 2.95 well east of the median rift in the south. There is an anomalous low measurement (0.40) located near the central axis of the ridge similar to a zone of low heat flow observed farther to the north.

In the Pacific a line of stations was run from Tahiti to Mexico and a number of these fell close enough to measurements made by the Bullard probe technique that comparisons could be made. In general the results of the two techniques are compatible at nearby stations. A profile of the values along this line (see attached Fig. 3) shows that values vary quite smoothly along the line with the exception of a single anomalous probe. A broad, high heat-flow zone is found over the East Pacific Rise as noted by earlier Scripps Institution of Oceanography investigators.

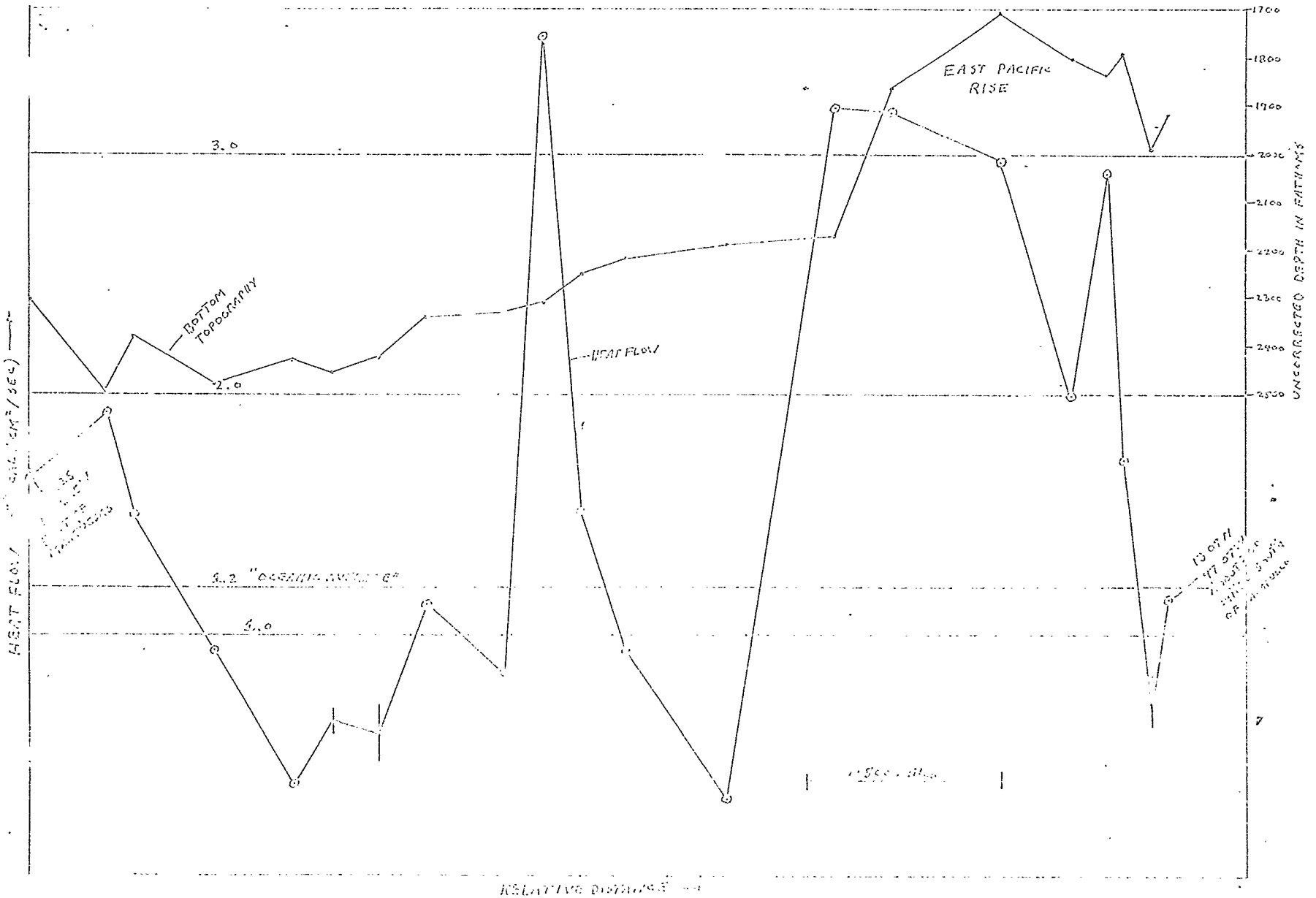
EAST PACIFIC RISE
3.0
BOTTOM TOPOGRAPHY
2.0
HEAT FLOW
4.2 "OCEANIC ANGLE"
4.0
1700
1800
1900
2000
2100
2200
2300
2400
2500

Fig. 3

4. MARINE GEOLOGY AND BIOLOGY.

a. Structure and sediments.

During VEMA cruise 18, 377 piston cores, 37 dredge samples, 132 bottom trawls and 312 bottom camera stations were taken. In addition, II cores and 2 camera stations were taken aboard CONRAD during her initial cruise in December. Continuous measurement of depth with the PDR was carried out during these cruises as well as continuous seismic reflection profiling.

Several areas were studied in some detail during the VEMA cruise, including the Argentine continental margin and the Argentine Basin where anomalous thicknesses and anomalous distributions of sediments were found, the Hikurangi and Kermadec Trenches, where a deep sea canyon was traced and its development studied, and several of the archipelagic plains of the west equatorial Pacific. A search was made for additional domes in the Gulf of Mexico, similar to those found in the Sigsby deep, and the New England-Kelvin seamount group was examined because of its apparent relationship to a zone of transcurrent faulting. The data from this expedition are still in the process of evaluation and analysis but have already revealed many important facts concerning the variability of sediment thickness, the correlation of character of echo sounding records and deep sea photographs, and the structure and topography of deep sea trenches. Numerous samples of bottom sediments from the Lamont collection have been sent to investigators and institutions throughout the world for special analysis.

In addition to routine reduction of the topographic data, considerable effort has been devoted to the study of the South Atlantic Ocean, including preparation of maps and drawings of critical areas and to several critical areas of the North Atlantic. The data now being obtained by the International Indian Ocean Expedition are being assembled into a physiographic diagram,

similar to those already published for the North and South Atlantic, which should be completed late in 1963.

Studies of the sediments and fauna of the Argentine shelf have been completed and are now in press. These include investigations of molluscs as well as studies of the extent of sea level lowering during the Wisconsin period of glaciation. The Argentine shelf lends itself to such studies much better than many others because the break from shelf to slope occurs at greater than usual depths. Thus, instead of dealing with a very narrow zone near the shelf edge, one deals with a rather broad zone on the shelf proper.

Profiler measurements in the vicinity of the Grand Banks earthquake of 1929 have further increased understanding of subsequent events. One major problem, not previously understood, was why one cable, only a few miles down the slope from others which broke at the time of the earthquake, did not break until 59 minutes later. It has been found (see attached Fig. 4) that the latter were on a large sedimentary sheet which slid down the slope while the former was a few miles in front of the toe of the slide. It was not broken until the turbidity current - which must have started up-slope from the slide - reached it at a later time.

The transcurrent fault at 40° N. was examined in some detail. Its presence is supported by topographic, magnetic, refraction, and reflection data and by geological data ashore. The fault extends along the New England-Kelvin Seamount group at least 400 miles from shore and west to the Susquehanna River in Pennsylvania. It is of special significance since it crosses the margin and extends from continent to ocean. Its age appears to be early Paleozo and it may allow dating of events in the North American Basin with a higher degree of accuracy than previously attainable.

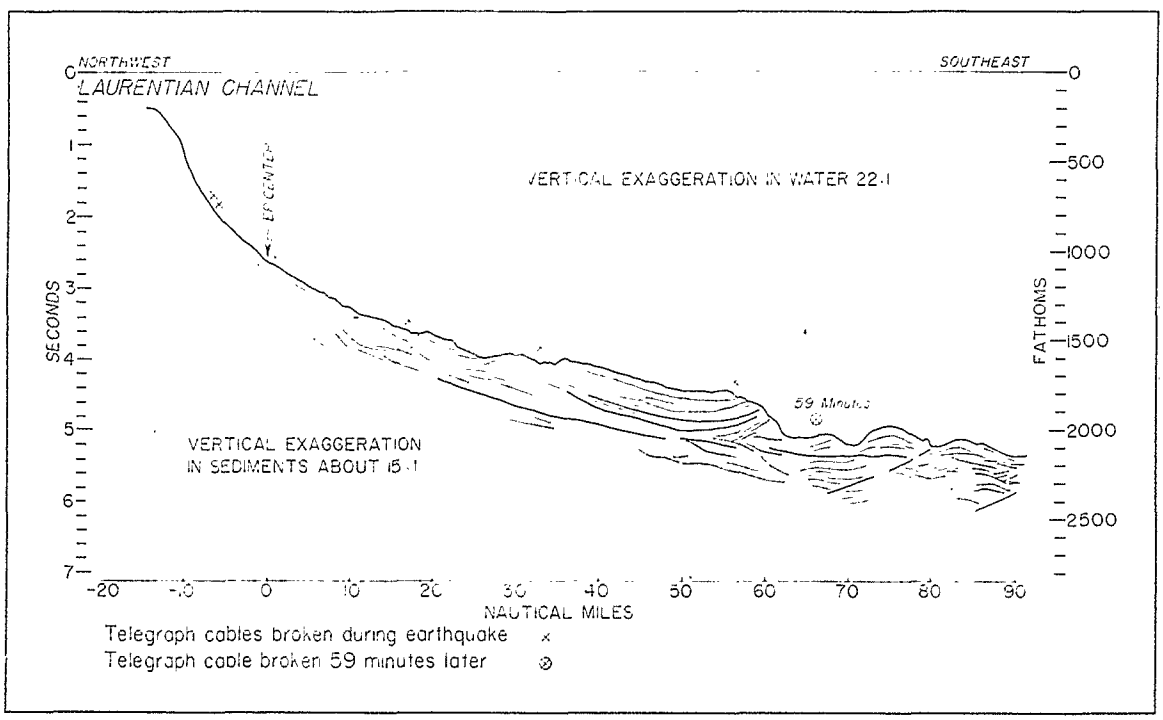
NORTHWEST
SOUTHEAST
LAURENTIAN CHANNEL
EPICENTER
VERTICAL EXAGGERATION IN WATER 22:1
59 Minutes
VERTICAL EXAGGERATION
IN SEDIMENTS ABOUT 15:1
SECONDS
FATHOMS
NAUTICAL MILES
Telegraph cables broken during earthquake ×
Telegraph cable broken 59 minutes later ⊗

Fig. 4

The structure of the Blake Plateau is becoming a little clearer. The combined refraction, gravity, and magnetic results are beginning to show a structure that can be related to that to the north and the results from Florida and the profiler results, which are exceedingly good, are showing the nature of the upper few thousand feet of the bottom in great detail. This area has been a difficult one in which to work on account of the presence of the Gulf Stream and of the presence of carbonates as opposed to the clastics to the north.

b. Marine ecology and biology.

The plankton program is continuing the environmental study of those shellbearing groups that contribute significantly to the organic remains of pelagic sediments. Efforts so far have concentrated on the planktonic Foraminifera, Pteropoda and Coccolithophoridae, which together make up virtually the entire fossil assemblages of calcareous oozes. About 450 plankton samples were collected during the 18th cruise of VEMA. These consist of surface (0-10 m) and oblique (0-300 m) tows, usually taken concurrently at each station. Several dozen serial opening - and - closing tows to 1000 m depth were also collected, particularly in the Indian and Pacific Oceans.

Further progress has been made in the refinement of the Lamont multiple opening-and-closing plankton sampler. This device has now been adapted to function in three possible modes of operation: 1) sampling several depth ranges during descent only; 2) sampling several depth ranges during ascent only; 3) sampling below a certain, preselected depth with a one-net sampler, with the net opening and closing if it moves shallower than the predetermined depth. The piston-type release mechanism has been adjusted to allow sampling of the 1000-2000 m depth range. (The previous maximum depth sampling was between

500 and 1000 m). This instrument is currently used on board the R/V ANTON BRUUN, VEMA, CONRAD, and ELTANIN.

Laboratory analysis has concentrated upon the identification and enumeration of the planktonic Foraminifera and Pteropoda. An automatic device for accelerating the sorting of planktonic specimens from liquid samples has been developed and is in use.

The acquisition of a Philips Norelco electron microscope has opened up new vistas in the exploration of deep-sea sediments. Minute fossils ranging in size from 3 to 40 microns, such as coccoliths, discoasters, silicoflagellates, diatoms, etc., have been identified. Studies are under way to relate their geographic distribution to bottom topography and sediment types. Electron micrographs of surfaces of sand grains are taken to relate these to their environmental mode of transport, abrasion, and deposition.

Sediment isolates of bacteria were studied and compared to terrestrial bacteria in terms of growth at various temperatures and salinities. For the most part the isolates from the sediments showed ability to grow at higher salinities and failed to grow in distilled water media. They also exhibited the same phenomenon described by Ritchie for marine molds, that is, they showed greater growth at high temperatures coupled with high salinities than at low salinities, and greater growth at low temperatures coupled with low salinities than at higher salinities. This is in contrast to the terrestrial organisms which show a greater growth at low salinity regardless of the temperature. Many of the terrestrial organisms did not grow at all over the range of salinities and only grew in the lower salinities, which is in contrast to the marine organisms which tended to grow over a wide range of salinities. In this regard, it is interesting to note that bacteria isolated from the

rocks dredged from the ocean floor behaved more like the terrestrial organisms than like true marine bacteria, that is while they did grow over a range of salinities they seemed to show better growth at the lower salinities regardless of the temperature.

One isolate, designated 169R, from core #169 VEMA 17, was found to produce a red pigment which resembled prodigiosin, a pigment produced by a common bacterial genus, Serratia, and not reported to be produced by other bacterial genera with the possible exception of some Streptomyces species. The isolate was intensively studied and found not to be a member of the genus Serratia as it is presently described. The pigment was studied for its absorption spectrum in the visible and ultra violet and was found to be almost identical in this respect to prodigiosin.

5. PHYSICAL AND CHEMICAL OCEANOGRAPHY

On VEMA cruise 18, 2142 bathythermograph slides were made, as well as 14 hydro stations, mostly in critical areas of the Caribbean to complete a study of the circulation of this area. In addition, continuous measurements of sea surface and keel temperatures were made for the entire cruise and temperature profiles of the total water column were made by the water probe of the thermograd on each of the 160 lowerings.

Several current meters for use on the ocean floor were designed, constructed, and remodeled during the year. The simplest type employed vanes to sense both the magnitude and the direction of the current and a modified deep sea camera recorded the results. The other group employed both vanes and drops as sensing elements. A new mechanism for providing drops was developed and the old mechanism was improved.

The vane-type meter was buoyed in Long Island Sound and left on bottom for the major part of a day during May and June by GOLDBERGER. On the first occasion, the currents were stronger than anticipated and much of the record is off scale. This was corrected for the other two and good records were obtained. The suspended-drop current meter was used successfully near the Hudson Canyon for three lowerings from GOLDBERGER in June and again in the same area between 80 and 850 fathoms in August. It was lowered once to 2400 fathoms from SIR HORACE LAMB off Bermuda where currents ranging from 2 to 8 cm/sec were measured.

The tide stations in Iceland and the Azores which were installed during the IGY are still being operated as well as a microbarovariograph in the latter location. Reduction of some of the earlier data from Bermuda, made between 1954 and 1961 have revealed sea level anomalies which appear to be unique in the history of sea level fluctuations. These studies utilize tide gauges data, air pressure fluctuation data and serial hydrographic observations over this interval.

Sixty-four large volume water samples were taken on VEMA for circulation studies as well as 36 samples for studies of strontium-90 content. These latter are expected to reveal information on vertical mixing rates and are also to be used for trace element studies.

6. PUBLICATIONS

Many papers were given at scientific meetings in this country and abroad. The abstracts of these papers are, in general, published in the minutes of these meetings and will not be reported here. The following includes only papers published or in press during 1962.

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Menzies, R. J., Abyssal bryozoa collected by expeditions of the Lamont Geological Observatory, 1. Bicellariellidae (Bugulidae of authors), Kinetoskias; Am. Mus. Novitates, No. 2130, p. 1-8. (1963)

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Heezen, B. C. and A. S. Laughton (in press) Abyssal plains; The Sea, v. 3.

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Ewing, J. and J. E. Nafe (in press) The unconsolidated sediments; The Sea, v. 3.

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7. FUTURE PLANS

VEMA will depart in February for another long cruise. She is scheduled to travel to Panama and then through the Panama Canal to Callao, Peru. This will allow her to make the passage from Callao to Tahiti planned for cruise 18 but not carried out due to adverse wind and currents and the limited range of the vessel. This range has now been increased by several thousand miles by addition of a waste heat evaporator and conversion of two large fresh water tanks to fuel oil.

From Tahiti VEMA will go to the Indian Ocean via Samoa and Manila to participate in the International Indian Ocean Expedition, then return to New York by way of Capetown, Madeira, and Lunenburg, Nova Scotia. She is due back about the middle of November.

CONRAD was originally scheduled to work in the North Atlantic and Caribbean for several months while the necessary corrections, additions, and alterations were being made. She was then scheduled to depart for the Indian Ocean via the North Pacific. At the time of this writing, the schedule has been altered by the sinking of USS THRESHER and CONRAD will be occupied in the search for this vessel for an undetermined period of time.

GOLDBERGER, although valuable for many experiments in local waters, has not proven to be an economical operation. It has been decided that she will be disposed of and that other arrangements will be made. It appears that ship time may be available from the Fish and Wildlife Service Laboratory in Sandy Hook, and the possibility of using the small vessels belonging to Hudson Laboratories and to New York University is being investigated.

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William L. Donn	Atmospheric and sea level fluctuations
Charles L. Drake	Geology, geophysics
John I. Ewing	Seismic measurements
Maurice Ewing	Geophysics
Charles Fray	Marine sediments
Robert Gerard	Physical oceanography
Bruce C. Heezen	Submarine geology
James Heirtzler	Geomagnetism
Marcus G. Langseth	Geothermal measurements
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